American Journal of Nursing Research, 2026, Vol. 14, No. 1, 10-19
Available online at http://pubs.sciepub.com/ajnr/14/1/2
Published by Science and Education Publishing
DOI:10.12691/ajnr-14-1-2

Sensory Stimulation to Reduce Delirium Post Liver Transplantation

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Received February 16, 2026; Revised March 18, 2026; Accepted March 25, 2026

Abstract **Background:** Post-operative delirium is a frequent complication after surgery especially liver transplantation, occurring in 15–20% of general patients admitted to ICU, and it has been associated with prolonged ICU and hospital length of stay, increased costs of care, and higher mortality rate. Sensory stimulation is a non-invasive, safe, inexpensive and straight forward approach widely used in caring for people post transplantation to reduce incidence of neurocognitive disorders, such as dementia and delirium. **Purpose:** to evaluate the effect of sensory stimulation to reduce delirium post liver transplantation. **Design:** A quasi-experimental design was utilized. **Setting:** Surgical Intensive Care Units of the National Liver Institute in Menoufia, Menoufia Governorate, Egypt. **Sample:** A convenient sample of 40 post liver transplant patients who were admitted to the ICU. **Instruments: (**1) A Semi Structured Demographic and Medical Data Sheet, (2) Simplified Acute Physiology Score II (SAPSII), (3) Richmond Agitation Sedation Scale (RASS), (4) Confusion Assessment Method in the ICU (CAM-ICU). **Results:** There was a highly statistically significant decrease in the mean score of delirium in the study group (0.30 ±0.10) compared to (4.15 ± 2.30) in the control group post intervention ($p<0.001$). Additionally, there was a highly statistically significant improvement in the incidence rate of delirium in the study group compared to the control group post intervention with the majority of participants in the study group (90%) compared to (20%) in the control group had no delirium. Also, there was a highly statistically significant reduction in the mean score of the ICU length of stay in the study group (6.70 ± 0.57) compared with the control group (8.50 ± 1.73) post intervention with ($P< 0.001$). **Conclusion**: sensory stimulation interventions had a significant impact on reducing the incidence rate, severity of delirium and ICU length of stay following liver transplantation. **Recommendation:** Sensory stimulation should be considered a standard practice post-operative for liver transplant patients, as it has been shown to reduce the incidence of delirium and promote better recovery outcomes.

Keywords: *Liver Transplantation, Post-operative Delirium, Sensory Stimulation*

Cite This Article: Nabawia S. Safan, Naglaa M. El Mokadem, Essam M. Salah El Deen, and Amal N. Abboud, "Sensory Stimulation to Reduce Delirium Post Liver Transplantation." *American Journal of Nursing Research*, vol. 14, no. 1 (2026): 10-19. doi: 10.12691/ajnr-14-1-2.

1. Introduction

Liver Transplantation (LT) is the only lifesaving treatment option for patients with end-stage liver disease, acute liver failure, and for selected patients with hepatocellular carcinoma in whom other curative treatment options have failed or are not suitable. Over the past decades, early post transplantation outcomes have significantly improved, while the 20-year survival rate still remains only approximately 50% [1].

The number of liver transplants worldwide shows extreme regional variation. As of 2024, USA, Europe, and Western Pacific had the largest number of liver transplants. The USA, with the largest number, had almost 9,383 liver transplants [2]. In Egypt, the Minister of health reviewed statistics for organ transplants conducted in 2024, between First of January and the 5th of December, a total of 1,271 transplant procedures were performed for both Egyptians and foreigners, including: 420 liver transplants and 1,194 kidney transplants [3].

Despite the tremendous development of patient selection, surgical techniques, preoperative management, and immunosuppressive therapies, LT remains a complex surgery associated with multiple complications that can sometimes lead to patient morbidity and mortality. These complications include surgical-specific complications such as vascular and biliary complications, acute graft failure, infections, acute kidney failure, plumonary complications, neurological complications as seizures, stroke, central nervous system (CNS) infections, ICU-acquired weakness, hepatic encephalopathy and delirium which are the common neurological consequences that

occur most frequently post LT [4].

Post-operative Delirium (POD) is a frequent complication after surgery especially liver transplantation, occurring in 15–20% of general patients admitted to ICU. There is a high incidence of postoperative delirium in liver transplant recipients, ranging from 7.5 to 47% and it has been associated with prolonged length of ICU and hospital stay, increased costs of care, and higher complications and mortality [5].

Delirium in liver transplant recipients is often associated with metabolic disorders, infection, organ failure, hepatic or uremic encephalopathy, and admission to an intensive care unit (ICU), as well as the neurotoxic side effects from the use of immunosuppressive drugs such as calcineurin inhibitors or high-dose steroids [5]. Previous studies have linked POD to the use of antidepressant drugs before surgery, history of pre-LT porto-systemic encephalopathy, alcohol abuse, re-transplantation or high APACHE II score and high Model for End Stage Liver Disease (MELD) score [6].

Given the high prevalence of delirium among critically ill patients, and its associated negative clinical outcomes, current practice guidelines recommend that prevention and early diagnosis of postoperative delirium is crucial to prevent patients from developing long-term complications and to initiate an effective treatment, so early diagnosis for delirium which can be routinely screened by using a validated screening tool such as the Confusion Assessment Method for the ICU (CAM-ICU) [7].

Prevention and management of delirium involves both pharmocological and non- pharmocological interventions, a limited number of studies supports the use of pharmocological interventions [8]. In recent years, non-pharmacological interventions have gained attention for their potential in preventing and managing delirium. Among these approaches, sensory stimulation has emerged as a promising strategy, it is a core component of many non-pharmacological interventions. Sensory stimulation techniques, including visual, auditory, olfactory, and tactile interventions, by engaging patients' auditory and visual senses that help enhance orientation, reduce confusion, and promote cognitive recovery. Previous studies have demonstrated the effectiveness of sensory stimulation in decreasing the incidence and severity of delirium among ICU patients [9] .

2. Significance of the Study

Liver transplant recipients are among the highest-risk surgical populations for developing delirium, with incidence rates reported as high as 10-47% . These patients have a history of hepatic encephalopathy, a condition characterized by cognitive impairment due to liver failure. This pre-existing brain vulnerability drastically lowers their threshold for delirium. Additionally, the surgical procedure itself involves massive fluid shifts, hemodynamic instability, and a significant inflammatory response, all of whichcan disrupt the fragile blood-brain barrier and cerebral function. Post-operative delirium (POD) is a prevalent and devastating complication for liver transplant recipients, leading to increased mortality, prolonged hospital stays, and long-term cognitive decline [10].

Current prevention and management strategies are often fragmented and reactive. Reducing the incidence and severity of delirium will led to a safer recovery, preservation of cognitive function, a shorter and less traumatic ICU stay, and a faster return to a meaningful life [11]. This study generated new knowledge at the intersection of critical care, transplantation, and neuroscience nursing and providing a model for developing similar non-pharmacological interventions for other high-risk surgical populations.

3. Purpose of the Study

The purpose of the current study was to evaluate the effect of sensory stimulation to reduce delirium post liver transplantation.

4. Definition of Variables

Dependent Variables:

Delirium: is theoretically defined as" a change in cognition, along with disturbances of attention and awareness, characterized by reduced capacity to direct, focus, sustain, or shift attention as well as reduced orientation to the environment"[12]. In the present study, post LT delirium is operationally defined as the obtained individual score of confusion assessment method in ICU (CAM - ICU) scale. (0-2: no delirium, 3-5: mild to moderate delirium, and 6-7: severe delirium).

ICU Length of Stay is theoretically defined as "duration the patient spends in ICU" [13]. In the present study, ICU length of stay is operationally defined as mean or median number of patient's days from ICU admission till ICU discharge.

Independent Variable:

Sensory Stimulation: is theoretically defined as " the activation of one or more of the senses including taste, smell, vision, hearing and touch for the purpose of promoting arousal and behavioral responsiveness" [14]. In the present study, sensory stimulation is operationally defined as a designed intervention including stimulation of vision and hearing to reduce delirium post liver transplant three sessions a day (each session is 30 min) for seven consecutive days.

Research Hypotheses

1. Patients who receive sensory stimulation (intervention group) are expected to have less incidence of delirium compared to those who do not receive sensory stimulation (control group).
2. Patients who receive sensory stimulation intervention are expected to have less severity of delirium compared to control group.
3. Patients who receive sensory stimulation intervention have less ICU length of stay compared to those who do not receive sensory stimulation.
4. There is a relationship between incidence of delirium and preoperative MELD score.
5. There is a relationship between incidence of delirium and amount of sedative and amount of pain killer medication.

5. Methods

Research Design: A Quasi-experimental design (study /control) was used to examine the effect of sensory stimulation on incidence of delirium post liver transplantation.

Setting: The current study was conducted in the Surgical Intensive Care Units of the National Liver Institute in Menoufia, Menoufia Governorate, Egypt.

Sample: A convenience sampling of 40 patients who were admitted to surgical ICU at the National Liver Institute in Menoufia were approached over 16 months from the beginning of August 2023 to the end of November 2024. These patients met the following inclusion criteria: a) adult patients, age from 18 to 65 years old; b) able to communicate; and C) had a Richmond Agitation-Sedation Scale (RASS) score ≥ 3. Patients were excluded to participate in the study if they had any of the following conditions: a) diagnosed with dementia, delirium, or acute psychiatric illness at admission that consider a high risk for ongoing or increased severity of the psychiatric disorder after transplantation; b) diagnosed with end-stage cancer that would not improve with transplantation; and c) had severe hearing impairment which cannot be corrected by hearing aids because these patients can't respond to the auditory stimulation.

Sample Size calculation: Sample size was determined using G power analysis. The calculation was based on an 80% statistical power to detect a difference in the percent of patients receiving preventive measures. A significant level (Alpha) of 0.05 and small effect size were also incorporated into the calculation of the sample.

Instruments

Instrument one: A Semi Structured Demographic and Medical Data Sheet: includes data about patient's age, gender, past medical history (diabetes mellitus or cardiovascular disease), history of hypnotic drug use, and history of alcohol abuse, admission date, type of surgery, current diagnosis, duration of mechanical ventilation, and analgesic and sedative medications. Preoperative risk factors for delirium including severity of chronic liver disease (assessed using the Model for End Stage Liver Disease (MELD) scoring system) and diagnosis of preoperative hepatic encephalopathy (assessed and graded using the West Haven Criteria).

Instrument two: The Simplified Acute Physiology Score (SAPS) II: SAPS II was developed by [15] to assess the severity of disease for patients admitted to intensive care units during the first 24 hours after admission. It generates a point score ranging from 0 to 163 based on 17 variables: 12 physiological variables, 2 variables related to age, type of admission (scheduled surgical, unscheduled surgical, or medical), and 3 variables related to underlying disease (acquired immunodeficiency syndrome, metastatic cancer, and hematologic malignancy). The scoring system of the scale interpreted as: 29 had 10% mortality risk, 40 had 25% mortality risk, 52 had 50% mortality risk, 64 had 75% mortality risk, and 77 had 90% mortality risk.

The reported validity of SAPS II scale was high when tested in critically ill patients with Bravais-Pearson correlation Coefficient 0.873; $p < 0.0001$) [16]. The reliability of SAPS II scale was reported in a study of 22 bed general ICU at Stavanger University Hospital and internal consistency was evaluated using intraclass correlation coefficient (95% CI) of the scores was 0.84, $P < 0.0001$ for the total scale [17].

Instrument three: Richmond Agitation Sedation Scale (RASS): The RASS developed by [18] to measure the agitation or sedation level of mechanically ventilated patients in order to avoid over and under sedation. Also obtaining a RASS score is the first step in administering the Confusion Assessment Method in the ICU (CAM-ICU), a tool to detect delirium in intensive care unit patients. The scale system ranges from +4 to -5 and it is interpreted as+4: the patient is combative, +3: very agitated,+2 agitated ,+1 : restless, 0: alert and calm , -1 : drowsy ,-2: light sedation , -3: moderate sedation ,-4: deep sedation,-5: unarousable .

The RASS has excellent interrater reliability with ($r = 0.956$, lower 90% confidence limit = 0.948; $\kappa = 0.73$, 95% confidence interval = 0.71, 0.75) (Ely et al., 2003). Validity of RASS: face validity was tested by a survey of 26 critical care nurses, 92% and 81% agreement with the RASS scoring were found [19].

Instrument four: Confusion Assessment Method in the ICU (CAM-ICU): The CAM-ICU developed by [20] . It is the delirium assessment tool constructed with yes/no questions for use with nonspeaking mechanically ventilated ICU patients. The CAM-ICU form assesses delirium for four features: 1) acute onset or fluctuating course, 2) inattention, 3) disorganized thinking, and 4) altered level of consciousness, and is deemed positive when feature 1 and feature 2 and either feature 3 or 4 are present, with scores of 0-2: no delirium, 3-5: mild to moderate delirium, and 6-7: severe delirium. The CAM-ICU had high interrater reliability (kappa = 0.96; 95% confidence interval, 0.92-0.99) (Ely et al., 2001). Validity of CAM-ICU had sensitivities of 100%, specificities of 98% [20].

Ethical Consideration

Research Ethical Committee at the Faculty of Nursing granted written approval to conduct the study, with an assigned approval number (ERCNMA1000/11/1/5/23) and an official permission was obtained by the researcher from hospital director to conduct the study after explaining the purpose of the study. A written consent was obtained from patient to participate in the study after an explanation of the purpose, procedure and benefits of the study and the researcher explained to patients that participation in the study is voluntary and they can withdraw from the study at any time without any negative impact on their course of treatment. Confidentiality and anonymity of patient information was assured through coding all data and keeping all data in a secured cabinet.

Pilot Study

Pilot study was conducted on 10% (4 patients) to test practicability and applicability of the instruments and to estimate the time needed to fill in the study instruments, those patients were excluded from the final analysis.

Data Collection Procedure

An official letter was submitted from the Dean of the Faculty of Nursing to Dean of the Faculty of National Liver Institute in Menoufia including the purpose of the study and methods of data collection. Two equal groups of

20 patients each (study and control) were randomly selected from a sample of 40 patients undergoing liver transplantation. To prevent data contamination, the researcher initially worked with the control group. For the control group, the patients received routine hospital care. The study group received sensory stimulation intervention (auditory and visual stimulation 30 min three times a day for the first seven days' post liver transplantation. Demographic and medical data sheet of the participants were retrieved from the patient's medical record by the researchers. All participants were assessed by using instrument (two, three and four) before and after the intervention.

Control Group (Routine Care):

The control group received a routine hospital care, which includes administration of sedation, Analgesia, applying spontaneous breathing trial, caring of urinary catheter and tube feeding.

Study Group (Sensory Stimulation Intervention):

For the study group, sensory stimulation intervention was implemented along with usual care. The focus of the intervention was stimulating two senses (hearing and vision). The researcher gave an orientation session to the patient's family caregivers explaining the sequence of the intervention during the first meeting. The researcher explained the five actions that family caregivers can do to support the patients (discussion in simple words, providing reminders of the current time, date and location, bringing glasses or hearing aids when appropriate, showing patient family photographs, and chatting about familiar topics). The researcher gave the family caregiver a reorientation messages which aimed to help patients understand what is going on around them.

Participants received three stimulation sessions per day at (10 AM, 12 PM, 4 PM) for 7 consecutive days; this is the recommended duration that has been proven to be effective in reducing the incidence of delirium post liver transplantation [21]. Each stimulation session is 30 minutes. The interval between sessions was two hours, to ensure washout of the accumulation effect of previous stimuli.

Auditory stimulation was consisted of voices of family members. For each patient, one family member was trained about how to record a voice message. Corresponding to the message provided, two minutes required for each recording message: first part (2 minutes) including the patient's name (preferred name as recommended by the patient's family), hospital name, name of the admitted ICU, the day of ICU admission, and ICU surroundings. Second part (2 minutes) including reassurance message like: Do not be scared, It is OK., the nurses and doctors are here looking after you, please try to be calm as the nurses and doctors work to get you feeling better, and looking after you. Third part (2 minutes) including talking about shared memories. In the fourth part (4 minutes) they speak promising and encouraging words about the patient's recovery and future subjects. This message was recorded during the pre-bedside phase in the visitation room of the ICU in the first 24 hours after recruitment to the study and using a voice recorder.

The visual stimulation interventions including: first helping patients to wear vision aids (personal eye glasses/reading glasses); preparing and showing a visible and accurate handheld clock and calendar; displaying personal or family photographs; providing a book or magazine for reading. The researcher provided auditory and visual stimulation three sessions a day each session 30 minutes and then, the recorded content of intervention played for each patient separately using ahead phones to separate ICU noise, and recorder removed after the recorded message has been played. The demographic and medical data were collected from the patient's medical record. Also, both groups were assessed for RASS (instrument II), Simplified Acute Physiology Score (instrument III).

Data Analysis:

A statistical analysis was conducted on the data using SPSS version 22 on an IBM-compatible computer. Descriptive statistics, including frequencies and percentages, were used to present the data. Quantitative variables were expressed as means (x) and standard deviations (SD), and comparisons between two groups were made using an independent samples t test. Qualitative variables were compared with a Chi-square test ($\chi 2$) to examine the association between them. The relationship between variables was assessed using Pearson's than correlation coefficient (r). A P-value of less 0.05 was statistically significant.

6. Results

Table 1: shows that the mean age of the participants in the study and the control group was (45.55 ±12.65 and 46.95± 13.01) years old respectively. Regarding sex, more than half of the participants in both study and control groups were male 80% and 55% respectively. There was no statistically significant difference in the demographic characteristics between both groups (p value= >0.05).

Table 2: shows that about 40% and 60% of both study and control group had de-compensated liver cirrhosis respectively. Regarding past medical history, 20% of both study and control group had Diabetes Mellitus and hypertension (P= 0.40). Concerning preoperative HE about 30% & 55% of the study and the control groups had preoperative HE respectively. The mean duration of mechanical ventilation was (12.75 ± 2.35 & 15.90 ± 11.15) in both study and control group respectively (p=0.22). There was no statistically significant difference between the two groups regarding all clinical data (p value= >0.05).

Table 3: demonstrates that the mean MELD score was (15.70 ± 5.08 & 18.85 ± 6.57) in the study and the control group respectively pre intervention. The mean score of SAPS II was (31.35 ± 11.34&29.20 ± 12.72) in the study and the control group respectively pre intervention. The Richmond Agitation and Sedation Scale mean score was (1.95±1.03&1.60±0.75) in the study and the control group respectively. There was no statistically significant difference between both groups regarding the severity of disease and RAAS.

Table 4: Shows that there is a statically significant reduction in the amount of prescribed propofol to the study group post intervention (1580 ± 372.1) compared with the control group (2145 ± 823.6) (p=0.04). Also, significant reduction in the amount of prescribed midazolam was reported in both groups (22.75±9.63

&47.75±18.73) (p = 0.01). The amount of prescribed analgesic was reduced significantly in both groups post intervention (p = 0.02).

Table 5: Shows that there is a highly statistically significant decrease in the mean score of delirium in the study group (0.30 ±0.10) compared to (4.15 ± 2.30) in the control group post intervention (p<0.001).

Table 6: showed that there was a statistically significant decrease in the incidence of delirium in the first day and the 7th day in the study group compared with the control group post intervention (p=0.000).

Table 7: showed that there was a high statistically significant reduction in the mean score of delirium features in the 7th day in the study group (0.30 ±0.10) compared with the control group (4.15 ± 2.30) (p=0.000).

Table 8: Illustrates that there was a highly statistically significant reduction in the mean score of the ICU length of stay in the study group (6.70 ± 0.57) compared with the control group (8.50 ± 1.73) post intervention with (P< 0.001).

Table 9: illustrates that there was a statistically significant positive correlation between MELD score and the incidence rate of delirium for both groups post intervention with r =0.58** (p<0.001) and r=0.50* (p <0.05). Which indicate that the participants with a lower MELD score had lower incidence rate of delirium.

Table 10: shows that there was a statistically significant positive correlation between sedative (midazolam) and the incidence of delirium for the study group post intervention with r =0.56 at the 0.05 level (2-tailed). This indicates that increase amount of prescribed midzolam increases the incidence of delirium in the study group post intervention.

Table 11: illustrates that there was a statistically significant positive correlation between pain killer medication and the incidence of delirium for both groups post intervention. There was a statistically significant positive correlation between the amount of prescribed Fentanyl with r = 0.74 (p <0.001) in study group and in control group r = 0.56 (p <0.01). Also, there was a statistically significant positive correlation between Nalufin medication and incidence of delirium for the control group with r = 0.54 (p <0.01).

Figure 1: Shows that there is a highly statistically significant improvement in the incidence rate of delirium in the study group compared to the control group post intervention. The majority of participants in the study group (90%) have no delirium compared to (20%) in the control group. While there was a 10% of the participants in the study group experienced mild to moderate delirium compared to 45% of the participants in the control group post intervention.

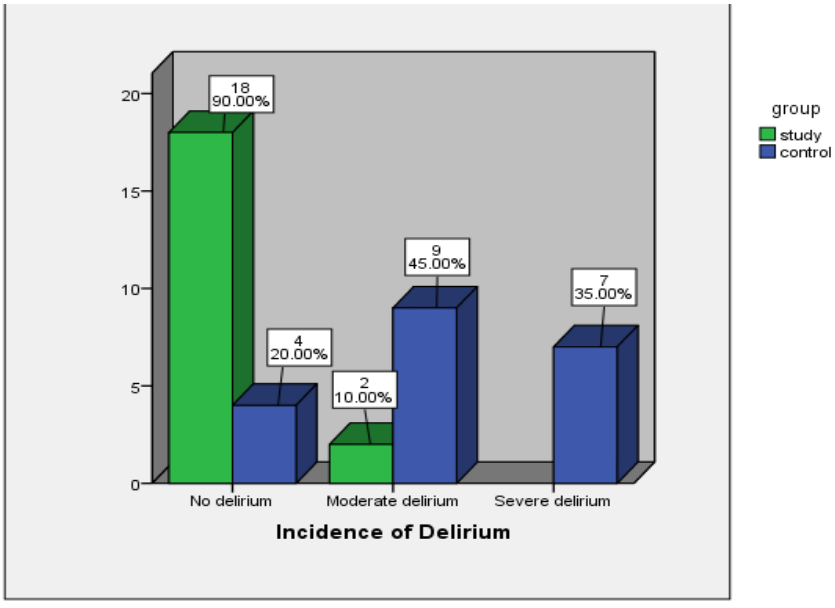


Figure 1. The Effect of Sensory Stimulation on the Severity of Delirium among the Studied Patients Post Intervention (N=40)

Table 1. Demographic Characteristics of the Studied Sample (N=40)

Demographic Characteristics	Study Group (n=20)		Control Group (n=20)		Test	P -value
	No	%	No	%	X^2	
Age					t test	
X ± SD	45.55 ±12.65		46.95± 13.01		0.35^{ns}	0.73
Gender						
Male	16	80%	11	55%	2.84^{ns}	0.09
Female	4	20%	9	45%		

Note: (ns): not significant (p value>0.05)

Table 2. Medical Data of the Studied Sample (N=40)

Medical Data	Study Group (n=20)		Control Group (n=20)		Test	P -value
	No	%	No	%		
Current Diagnosis						
- Decompensated Liver Cirrhosis (DLC)	8	40.0%	12	60.0%	X^2	
- Hepatic Cellular Carcinoma (HCC)	1	5.0%	0	0.0 %	5.05 ^{ns}	0.40
-Autoimmune Hepatitis (AIH)	3	15.0%	4	20.0%		
-Primary Sclerosing Cholangitis (PSC)	2	10.0%	0	0.0%		
- Hepatitis C Virus (HCV)	1	5.0%	0	0.0%		
-HCC & DLC	5	25.0%	4	20.0%		
Past Medical History						
-Diabetes mellitus (DM)	4	20.0%	5	25.0%	X^2	
-Hypertension (HTN)	2	10.0%	1	5.0%	0.44 ^{ns}	0.93
-DM & HTN	4	20.0%	4	20.0%		
-History of hypnotic use	0	0.0%	0	0.0%		
-History of alcohol use	0	0.0%	0	0.0%		
-No medical history	10	50.0%	10	50.0%		
Type of Surgery						
LDLT	20	100%	20	100%		
Preoperative HE					X^2	
No	14	70.0%	9	45.0%	2.55^{ns}	0.11
Yes	6	30.0%	11	55.0%		
Duration of mechanical ventilation in hours (X ± SD)	12.75 ± 2.35		15.90 ± 11.15		t test 1.23 ^{ns}	0.22

Note: (ns): not significant (p value>0.05)

Table 3. Severity of Disease and Co-morbidity & RASS Score of the Studied Sample Pre Intervention (N=40)

Items	Study Group (n=20) X ± SD	**Control Group (n=20)** X ± SD	**Independent t test**	**P -value**
MELD score	15.70±5.08	18.85±6.57	1.69 ^{ns}	0.09
SAPS score	31.35±11.34	29.20±12.72	0.56 ^{ns}	0.57
RASS score	1.95±1.03	1.60±0.75	0.91 ^{ns}	0.36

Note: (ns): not significant (p value>0.05)

Table 4. The Average Dose of Sedative and Analgesic Medication of the Studied Sample Post Intervention (N=40)

Items	Study Group (n=20) X ± SD	Control Group (n=20) X ± SD	Independent t test	P -value
Amount of sedative medication (mg/dl)				
Propofol (mg)	1580 ± 372.1	2145 ± 823.6	2.12 ^{s}	0.04
Midazolam amount (mg)	22.75± 9.63	47.75±18.73	2.71 ^{s}	0.01
Amount of Analgesic (mg/ day)				
Fentanyl (mg)	0.16 ± 0.10	2.78 ± 0.15	2.27 ^{s}	0.02
Nalbuphine (mg)	28.50 ± 9.33	37.50 ± 15.51	3.01 ^{s}	0.03
Perflgan (mg)	4650 ± 875	6000 ± 1337	3.77 ^{Hs}	0.001

Note: S: significant (p value<0.05). HS: High significant (p<0.001)

Table 5. The Effect of Sensory Stimulation on Delirium Mean Score of the Studied Patients Post Intervention (N=40)

Delirium	**Study Group (n=20)** X ± SD	**Control Group (n=20)** X ± SD	**Independent t test**	**P -value**
Post intervention	0.30 ±0.10	4.15 ± 2.30	6.946 ^{Hs}	.000

Note: Hs= highly significant (p<0.001)

Table 6. Incidence of Delirium among Both Study and Control Groups Post Intervention (N=40)

Days	Study Group (n=20)		Control Group (n=20)		X^2	P -value
	No	%	No	%		
1st day						
Absent	15	75.0%	13	65.0%	0.476	0.49
Present	5	25.0%	7	35.0%		
2nd day						
Absent	18	90.0%	13	65.0%	2.269	.000
Present	2	10.0%	7	35.0%		
3rd day						
Absent	15	75.0%	5	25.0%	10.00	0.002
Present	5	25.0%	15	75.0%		
4th day						
Absent	17	85.0%	5	25.0%	6.129	0.000
Present	3	15.0%	15	75.0%		
5th day						
Absent	17	85.0%	3	15.0%	14.545	0.000
Present	3	15.0%	17	85.0%		
6th day						
Absent	18	90.0%	3	15.0%	19.600	0.000
Present	2	10.0%	17	85.0%		
7th day						
Absent	18	90.0%	4	20.0%	19.798	0.000
Present	2	10.0%	16	80.0%		

Table 7. Mean Score of Delirium Features of the Studied Patients Post Intervention (N=40)

Delirium	**Study Group** X ± SD	**Control Group** X ± SD	**Independent t test**	**P -value**
Delirium1	2.20 ±0.52	2.30 ±0.47	0.636	0.529
Delirium2	2.05 ±0.39	2.65 ±1.04	2.413	0.021
Delirium3	2.10 ±0.78	3.20 ±0.95	3.982	0.000
Delirium4	1.90 ± 0.92	3.70 ± 1.38	4.866	0.000
Delirium5	1.50 ±0.82	4.25 ± 1.55	6.994	0.000
Delirium6	0.75±0.35	4.30 ± 1.72	8.158	0.000
Delirium7	0.30 ±0.10	4.15 ± 2.30	6.946	0.000
Friedman Test	82.539	47.049		
p-value	0.000	0.000		

Table 8. The Effect of Sensory Stimulation on ICU Length of Stay of the Studied Patients (N=40)

Items	Study Group (n=20) X ± SD	Control Group (n=20) X ± SD	Independent t test	P -value
ICU length Stay				
X ± SD	6.70 ± 0.57	8.50 ± 1.73	4.41 HS	0.001

Table 9. Correlation between MELD Score and Delirium Incidence Rate of the Study and Control Groups (N=40)

Items	Incidence of Delirium			
	Study Group (n=20)		Control Group (n=20)	
	r	P –value	r	P –value
MELD score	0.58**	<0.001	0.50*	<0.05

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 10. The Relationship between Sedative Medication and Delirium Incidence for the Study and Control Groups Post Intervention (N=40)

Sedative Medication	Incidence of Delirium			
	Study Group (n=20)		Control Group (n=20)	
	r	P –value	r	P –value
	0.29	0.20	0. 46	0.84
Midazolam	0.56*	0.01	0.20	0.38

Note: **. Correlation is highly significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 11. The Relationship between Pain Killer Medication (Analgesic) and Incidence of Delirium for the Study and Control Groups Post Intervention (N=40)

Pain killer Medication	Incidence of Delirium			
	Study Group (n=20)		Control Group (n=20)	
	r	P –value	r	P –value
Fentanyl	0.74**	<0.001	0.56**	<0.01
Nalufin	0.35	>0.05	0.54**	<0.01
Perflgan	0.07	>0.05	0.26	>0.05

**. Correlation is highly significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Discussion

Postoperative management of liver transplant recipients, with reported incidence rates ranging from 10% to 50% far from being a transient or benign complication, delirium has been associated with prolonged hospital stays, increased morbidity, higher healthcare costs, and in some cases, increased mortality. Integrating structured sensory stimulation into post-transplant care protocols may serve as a valuable adjunct to medical management, particularly given the vulnerability of this patient population to neurological complications [5].

Effect of Sensory Stimulation on Incidence and Severity of Delirium

Delirium is a common and serious complication following liver transplantation. Sensory deprivation in ICUs, such as reduced exposure to natural light, limited communication, and monotonous environments, can significantly contribute to the development of delirium. Sensory stimulation interventions such as orientation cues, auditory, visual stimuli, and tactile interaction have been shown to help maintain cognitive function and reduce the risk of delirium. In post-liver transplant patients, implementing structured sensory stimulation programs may enhance patient orientation, decrease anxiety, and promote neurological recovery [9].

The findings of the present study demonstrate a statistically significant reduction in both the incidence and severity of delirium among patients in the study group following the administration of a sensory stimulation intervention. These outcomes validate the proposed research hypotheses and align with a growing body of evidence supporting the efficacy of such interventions in critical care settings. Consistent with the current results, previous investigations have reported similar benefits. For instance, [22,23,24,25] examined the impact of structured sensory stimulation on delirium status among intensive care unit (ICU) patients and concluded that such interventions are associated with a diminished frequency and shortened duration of delirium episodes. Furthermore, [26,27], who explored sensory stimulation as an integral element of multicomponent preventive strategies, similarly observed notable reductions in both delirium incidence and duration.

Conversely, the present findings diverge from those reported by Liang et al. (2021), whose evaluation of a sensory stimulation program in a surgical ICU revealed no statistically significant difference in delirium incidence between the intervention and control groups. This discrepancy may be attributed to baseline clinical disparities between groups in the Liang et al. study; notably, the intervention group exhibited a higher prevalence of physical risk factors, including elevated PRE-DELIRIC scores, which may have mitigated the potential prophylactic effects of the sensory stimulation protocol. Such confounding variables underscore the complexity of delirium pathogenesis and the importance of considering individual patient risk profiles when interpreting intervention outcomes.

Effect of Sensory Stimulation on ICU Length of Stay

Reducing the ICU length of stay remains a key target in improving patient outcomes and optimizing healthcare resource utilization. Sensory stimulation has emerged as a promising non-pharmacological intervention that may positively influence ICU length of stay by reducing the incidence of complications such as delirium, enhancing patient orientation, and supporting faster neurological recovery [26].

The present study hypothesized that patients receiving sensory stimulation interventions would experience a shorter duration of ICU length of stay compared to those in the control group. The findings prove this hypothesis, demonstrating a highly statistically significant reduction in ICU length of stay among the intervention group comparative to the control group. These results align with prior evidence reported by [28,29,30], whose investigations into the effects of sensory stimulation on ICU outcomes similarly revealed that such interventions contribute to a decreased length of ICU stay in the study group compared to the control group.

The Relationship between MELD Score and Delirium Post Liver Transplantation

Model for End Stage Liver Disease (MELD) score, which represents the severity of liver disease, affects the priority allocation of the liver and predicts the mortality of patients preparing for LT. Previous studies have shown that various preoperative risk factors can lead to delirium after LT from these factors was high MELD scores [5].

The present study hypothesized a relationship between the Model for End-Stage Liver Disease (MELD) score and the onset of delirium following liver transplantation. The findings supported this hypothesis, revealing a statistically significant positive correlation between higher MELD scores and the incidence of postoperative delirium in both the study and control groups following intervention. These results are consistent with previous research by [31,32,33,34], who examined the incidence and risk factors for delirium after liver transplantation and similarly concluded that elevated MELD scores are associated with an increased risk of postoperative delirium.

The Relationship between Sedation, Analgesia and Incidence of Delirium Post Liver Transplantation

Analgesia and sedation are important therapies used in critically ill patients; however, too much sedation is associated with a longer duration of mechanical

ventilation and a longer intensive care unit stay. Patients in the ICU, particularly those with mechanical ventilation, have a rate of delirium as high as 80%, in addition to greater mortality, a longer duration of hospital stay, greater hospital costs and poor long-term outcomes [35].

The findings of the current study demonstrate a positive correlation between the cumulative dose of sedatives and analgesics and the subsequent incidence of delirium following liver transplantation. This result aligns with a substantial body of evidence, including the work of [36,37,38,39,40], which collectively suggests that higher exposure to sedative and analgesic agents is a significant risk factor for postoperative delirium in this population.

However, it is important to recognize that the relationship between sedation, analgesia, and delirium is complex and not entirely unidirectional. Some studies have presented different findings, suggesting that the association may be modified by drug selection, dosing strategies, and patient-specific factors. For instance, while deep sedation is consistently linked to poorer outcomes, certain analgesia-first or "no sedation" protocols have been associated with reduced delirium incidence compared to standard sedative regimens [41].

The conflicting findings in the literature may be attributed to several factors, including heterogeneous study populations, variations in the timing and tools used for delirium assessment, and the inherent difficulty in disentangling the effects of the medications from the severity of the underlying illness that necessitated their use. In the context of liver transplantation, these factors are further complicated by unique patient pathophysiology, such as pre-existing hepatic encephalopathy and altered drug metabolism, which can significantly influence both sedation requirements and delirium vulnerability. Therefore, while our findings support the cautious use of sedatives and analgesics, they also underscore the need for individualized titration strategies that prioritize analgesia and minimize deep sedation to potentially reduce the burden of postoperative delirium.

Limitation of the Study

- The findings of the current study are limited in their generalizability because of the convenient sample. The lack of random sampling may contribute to sample selection bias and limits the generalization of the findings.
- Participants were recruited from a single hospital; thus, findings should be interpreted cautiously.

Conclusion

This study highlights the significant impact of sensory stimulation interventions in reducing the incidence and severity of delirium following liver transplantation. Patients who received structured sensory stimulation exhibited improved orientation, reduced agitation, and a lower risk of developing delirium and reducing ICU length of stay compared to those who received standard care.

Recommendations

- It is suggested that Sensory stimulation should be considered a standard part of post-operative care for liver transplant patients, as it has been shown to reduce the incidence of delirium and promote better recovery outcomes.
- Awareness programs should be developed to educate healthcare providers and caregivers about the early signs of delirium and the benefits of non-pharmacological interventions.
- Hospitals should adopt evidence-based protocols that integrate sensory stimulation as part of holistic care for critically ill patients.

Implication for Nursing Practice

- Nurses should receive training on how to apply sensory stimulation techniques (such as orientation cues, soft music, touch, and familiar voices) as part of routine ICU care.
- Regular cognitive and sensory assessments should be integrated into nursing care plans to detect early signs of delirium.
- Nursing staff should collaborate closely with multidisciplinary teams to individualize sensory interventions based on patient needs, preferences, and medical status.
- Documentation and evaluation of sensory interventions should be included in nursing records to monitor their effectiveness.

Implication for Future Research

- Further studies with larger sample sizes and diverse populations are needed to confirm the long-term effectiveness of sensory stimulation in preventing delirium post-liver transplant.
- Comparative studies could explore which types of sensory stimulation (auditory, tactile, visual, etc.) are most effective for specific patient groups.

Exploration of technological tools (e.g., virtual reality, personalized music therapy apps) could provide innovative ways to enhance sensory input and reduce delirium risk.

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